United States Patent [19]

Kolpakov et al.

[11] **4,094,938**

[45] **June 13, 1978**

[54] **METHOD AND APPARATUS FOR LINING LADLES**

[76] Inventors: **Serafim Vasilievich Kolpakov,** ulitsa Ryazanskaya, 12; **Zinovy Lvovich Gurkov,** ulitsa Parkovaya, 4, kv. 42; **Oleg Leonidovich Bondarenko,** ulitsa M. Gorkogo, 13/2, kv. 1; **Vladimir Viktorovich Valtsov,** ulitsa Anosova, 2, kv. 25; **Alexandr Mikhailovich Pozhivanov,** ulitsa Zhelyabova, 16, kv. 8; **Eduard Dmitrievich Gugnin,** ulitsa Gagarina, 167, kv. 8; **Stanislav Vyacheslavovich Radilov,** ulitsa Tereshkovoi, 38b, kv. 34; **Alexandr Andreevich Bogdanov,** ulitsa Parkovaya, 6, kv. 4, all of Lipetsk, U.S.S.R.

[21] Appl. No.: **691,079**

[22] Filed: **May 28, 1976**

Related U.S. Application Data

[63] Continuation of Ser. No. 449,466, Mar. 8, 1974, abandoned.

[51] **Int. Cl.**^{2} **F27D 1/16**

[52] **U.S. Cl.** **264/30;** 264/40.1; 264/309

[58] **Field of Search** 264/30, 309, 268, 269, 264/40.1

[56] **References Cited**

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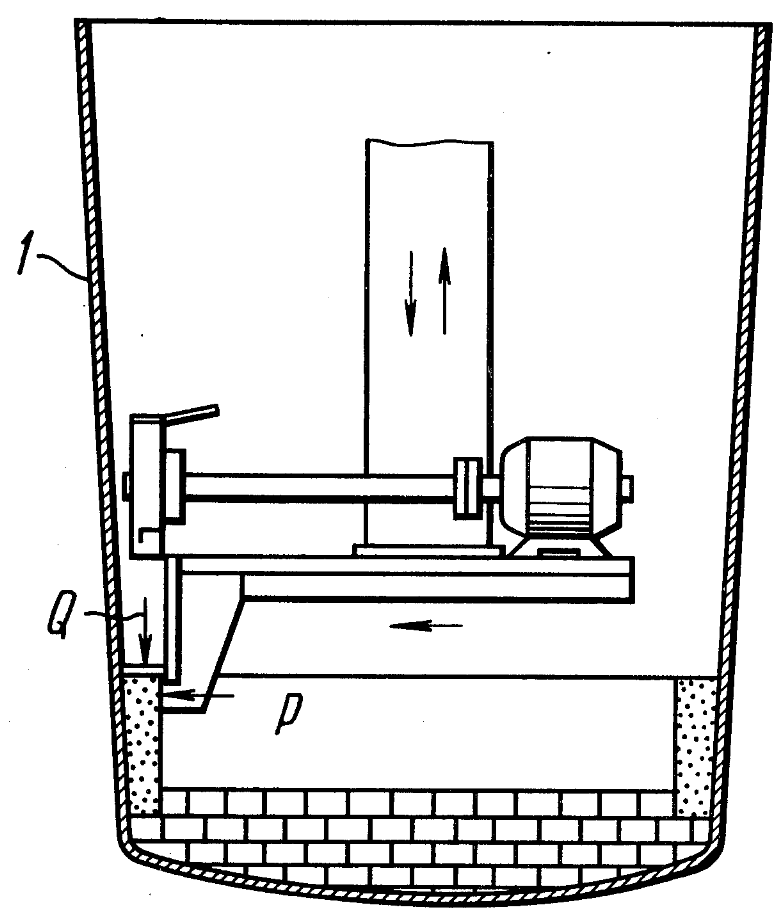
Primary Examiner—Thomas P. Pavelko
Attorney, Agent, or Firm—J. Harold Nissen

[57] **ABSTRACT**

The method consists in that a refractory mass is delivered by a sand-blast head along the ladle lining surface and parallel thereto, and, simultaneously, the sand-blast head is imparted such a complex movement inside the ladle as to fill the lining continuously along a helical trajectory and over the entire height of the ladle from the bottom to the top. A backing shaping element is positioned behind the head to ensure a predetermined narrow gap that is to be filled with the refractory mass.

The apparatus for effecting the method is mounted on a platform installed inside the ladle on a hollow supporting rod through which the mass is fed to the sand-blast head. The head feeds the mass to apply the same to the inner surfaces of the ladle, while the backing shaping element limits the gap to be filled with the mass behind the head. Provision is made for a contact sensor of the current level of the lining plane, and controlled drives of the platform rotation, rod lifting and change in the radial jet of the mass thrown out of the sand-blast head.

6 Claims, 7 Drawing Figures



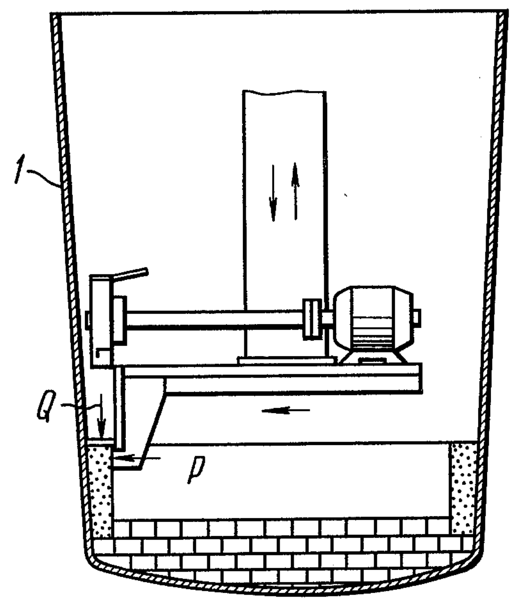


FIG. 1

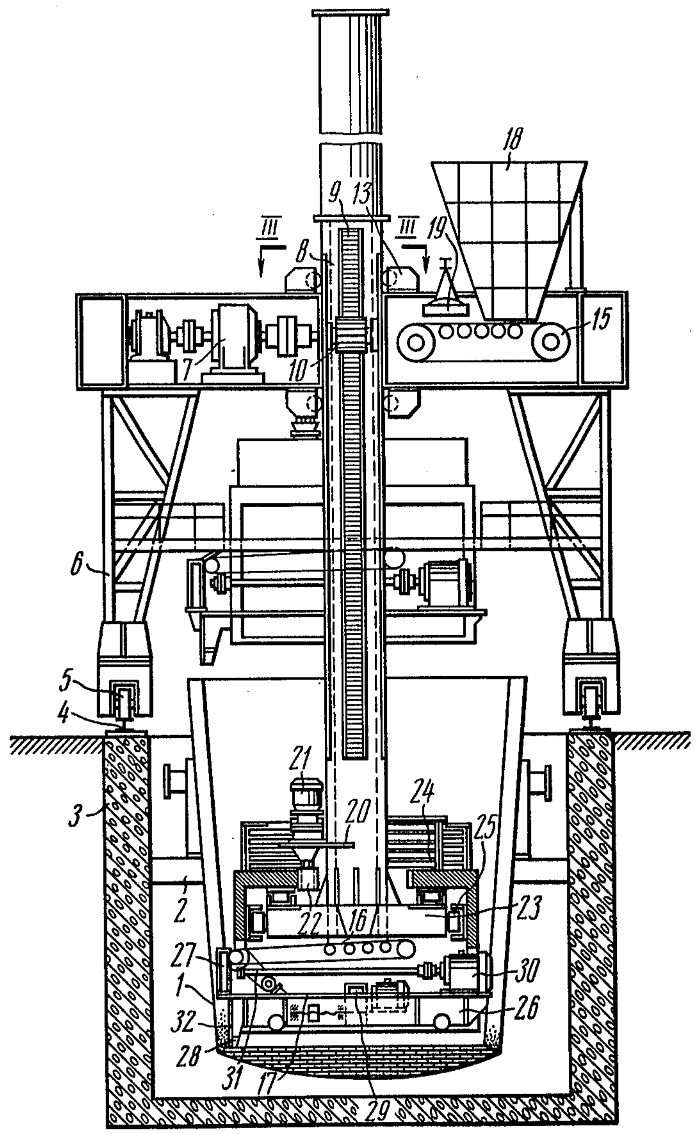

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FIG. 2

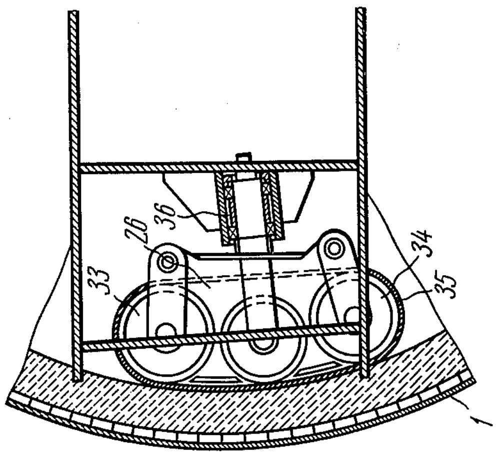

FIG. 6

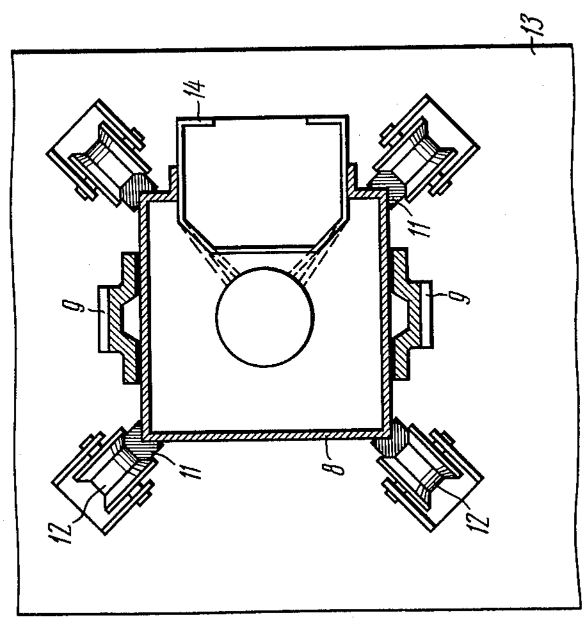

FIG. 3

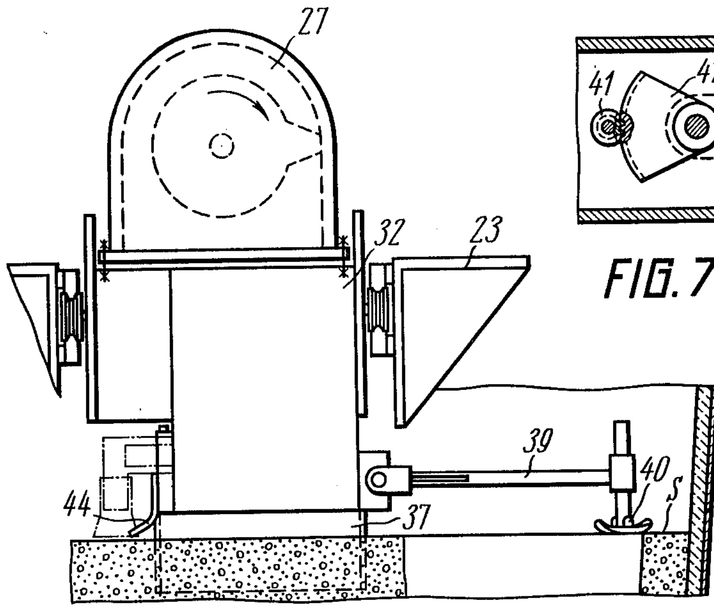

FIG. 4

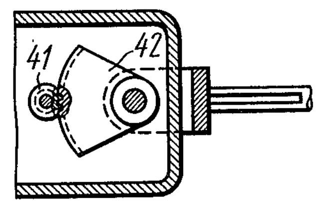

FIG. 7

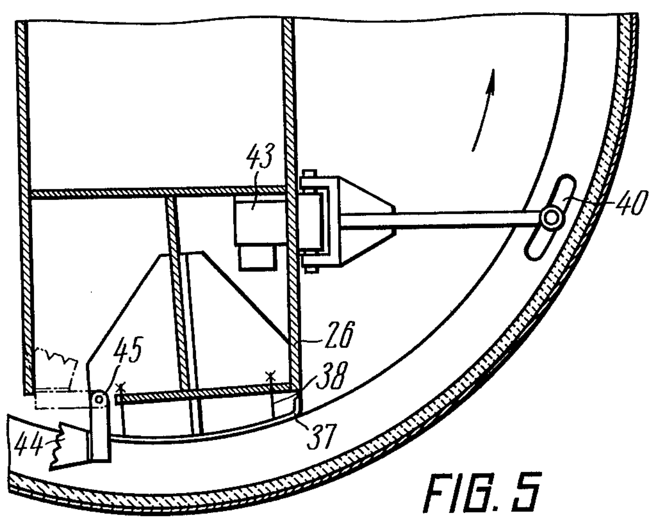

FIG. 5

METHOD AND APPARATUS FOR LINING LADLES

This is a continuation of the applicants' earlier patent application Ser. No. 449,466, titled "Method for Lining Ladles and Apparatus for Effecting Same", filed Mar. 8, 1974, now abandoned.

The present invention relates to the technology of making linings of steel-teeming or mixing ladles, ladles adapted to handle non-ferrous metals, as well as steel furnaces of a circular cross-section.

More particularly, the present invention relates to a method for lining the said and similar objects with a refractory mass fed from a sand-blast, head, and an apparatus for carrying out the method.

Known are several methods for lining the ladles with a refractory mass (cf. "Tchernye Metally", No. 16, p. 11, 1969; Translation No. 6600 of the catalogue of the Badische Machinenfabrik Company, Tchermetinformatzia, 1971), according to which methods the refractory mass is tramped by a sand-blast head in the space confined by the ladle wall, and a special pattern U.S. inserted in the ladle.

In accordance with this conventional technology the lining is tramped from below while the sand-blast head is disposed at the top, which makes the refractory mass thrown out of the sand-blast head at a high speed, passing through a narrow slot over a rather long distance before it gets onto the lining base surface. In this case the possibility of the refractory mass partial flow hit against the ladle wall or the pattern is not excluded, which reduces the speed of the mass flow and results in worse quality of the lining at the lower portion of the ladle.

Besides, the lining quality depends upon many other factors such as moisture content of the refractory mass, the degree to which the sand-blast head is loaded, and the rate of displacement of the sand-blast head relative to the lining plane. The optimum values of these parameters should vary within narrow limits, a deviation of at least one of them from the optimum value leads to poor-quality lining.

In the conventional methods the lining is tramped by only one active force, i.e. the impact force developed by the sand-blast head and applied along the wall of the ladle.

Also known is an apparatus employing a sand-blast head for successively lining ladles by separate circular layers.

In the conventional apparatus the ladle is turned relative to the sand-blast head and a snaping support, the sand-blast head is imparted a step-like rise, and the refractory mass is thrown at an acute angle with respect to the surface of the ladle walls being lined (cf. French Pat. No. 1,483,584).

The conventional apparatus has a number of disadvantages, for instance, that the successive step-like filling of tramped lining rings in turn results in a lower efficiency of the apparatus.

Rejection of the refractory mass by the sand-blast head at an acute angle relative to the surface of the ladle wall being lined decreases the degree of the mass tramping in the space between the ladle wall and the support, and may lead to considerable scattering of the refractory mass.

Besides, the rotation of the ladle being lined relative to the sand-blast head results, on the one hand, in technological and structural difficulties encountered when centering and supporting the ladle, and, on the other hand, in a more limited field of application of the apparatus for lining ladles of a relatively large size and weight.

The main object of the present invention consists in the provision of a method of filling linings that makes it possible to obtain high-quality lining of ladles along the entire height thereof owing to a uniform and high density of the lining effective layer.

Another object of the present invention is to provide a method tht allows to improve working conditions thanks to reduced scattering of the refractory mass by the sand-blast head during the lining process effected from the top.

Still another object of the present invention is to provide an apparatus for effecting the above method, that makes it possible to minimize auxiliary and preparatory operations during lining and, therefore, to raise the efficiency of the apparatus.

Yet another object of the present invention is to provide an apparatus that allows to dispense of the use of patterns inserted into the ladle and technological operations involved thereby.

Still another object of the present invention is to provide a relatively general-purpose apparatus applicable for filling linings of diverse parameters in ladles and furnaces of various types and sizes.

These and other objects are accomplished: that, in accordance with the present invention, the method for lining ladles with a refractory mass lies in that the mass as fed into the space confined by the inner surface of the ladle and the backing element by means of a sand-blast head moved along the inner circumferential perimeter of the ladle, to form a lining layer, the method being characterized in that in addition to its movement along the inner circumferential perimeter, the head is simultaneously imparted a continuous vertical movement along the height of the ladle, the distance between the sand-blast head and the lining surface being maintained constant, thereby ensuring continuous and successive filling of the lining along the helical line over a entire height of the ladle.

Thus, by maintaining constant the distance from the sand-blast head to the prevailing surface of the lining the latter has a higher quality (uniform density) as, when being thrown over a short distance, the refractory mass flow is not reflected by the walls of the ladle and pattern, is not slowed down due to air resistance, falls with a higher density and, consequently, delivers a stronger blow because in the course of a short-distance flight it has no time to scatter into fragments and the aerodynamic resistance is comparatively low.

The method according to the present invention is also characterized by that in the course of lining the refractory mass, fed into the said space, is subjected to simultaneous action of at least two active forces, of which one is the impact force developed by the sand-blast head and applied along the ladle wall being lined and parallel thereto, and the other one is applied in the direction normal to the ladle wall in the area where the lining is being tramped.

Simultaneous application of two active force attributes to additional tramping of the refractory mass in the space, thereby improving its quality.

The apparatus for lining ladles with refractory mass in accordance with the above method, comprising at least one sand-blast head with a mechanism for rotation thereof, and a backing shaping element connected to the sand-blast head to move together therewith, is characterized according to the present invention, in that it is provided with an adjustable mechanism for continuous movement of at least one sand-blast head along a helical line over the ladle surface being lined, and a mechanism for controlled movement of the sand-blast head together with the shaping support in the direction normal to the plane of the lining layer being filled.

This allows to dispense with the use of common patterns and, consequently, their manufacture, installation in the ladle, centering in the latter and subsequent removal therefrom. Therefore, the operating area for storing the patterns becomes unnecessary, the time required for preparatory and auxiliary operations is reduced, the hoisting equipment for handling the patterns is no longer needed, and the amount of manual operations is decreased. All this makes it also possible to make linings of any desired profile or taperness.

In accordance with one of the variants of embodiment of the invention the apparatus comprises a turnable platform disposed in the lower portion of a vertical supporting rod, placed inside the ladle being lined, and provided with a carriage mounting the at least one sand-blast head which is continuously supplied with the refractory mass and provided with a drive to continuously move the rod together with the platform in the vertical direction and, simultaneously, to rotate the turnable platform about the vertical rod axis.

This embodiment, by employing most rational constructive elements, allows to carry out the above method for lining ladles, to have a constant distance between the sand-blast head and the actual plane of lining, and to line ladles of various types and sizes.

In accordance with another variant of embodiment of the present invention the apparatus is characterized in that the supporting rod is made hollow, and a belt conveyor is installed at the point of outlet of the hollow rod, the conveyor supplying the refractory mass fed through the hollow rod to the sand-blast head.

The hollow rod serves a double purpose and is used as a rod for raising the platform with the sand-blast head and as a pipe through which refractory mass is fed to the belt conveyor without any difficulties encountered in the case when the rod is stationary and the conveyor moves relative to the vertical axis of the rod.

In accordance with still another variant of embodiment of the present invention the shaping element is provided with rotating rollers whose axes are disposed vertically relative to the ladle surface being lined, and are enbraced by a flexible band in such a manner that the element can freely move on the rollers when the shaping element is rolling over the lining being filled, the shaping support being connected to the carriage of the turnable platform by means of a joint whose working axis is normal to the support surface of the band of the shaping element, the shape of the operating surface of the shaping support being identical to the circumferential line of the lining.

This embodiment of the rotating rollers embraced by the flexible band makes it possible not to damage the lining due to elimination of the band slippage over the lining when the shaping support rotates together with the platform and the sand-blast head relative to the former, while employment of the joint allows the shaping support to self-adjust while moving along the helical line.

Besides, in accordance with the present invention, the hollow rod may be made of a box-like rectangular cross-section, and have toothed racks disposed along its entire length at the opposite edges to mount the rod lifting mechanism, the rod having prismatic guides fastened to the rod angles, and the support race having guiding rollers oriented along the diagonals of the rod cross-section and interacting with the guides during the vertical rod movement.

In this constructive embodiment the toothed racks are used to ensure reliability and simplicity of operation, and the prismatic guides are mounted at the angles to make the rod more rigid, and to sustain the load through more rigid elements of the rod cross-section. The guiding rollers of this cross-section protect the rod against variable torques when the platform is rotating together with the sand-blast head, decrease the number of the rollers employed, and ensure a high-quality centering of the rod relative to the vertical axis of the apparatus during the assembly of the latter.

In accordance with yet another variant of embodiment of the invention the sand-blast head and the elements connected thereto are mounted on the edge of the carriage so that it can move diametrically on the turnable platform relative to the ladle being lined.

This makes it possible to line ladles of various types and sizes and, besides, to make local changes in the lining being made.

In accordance with another variant of embodiment of the present invention, the carriage has an overhanging lever secured turnably in the diametrical plane of the platform, having at its end a contact shoe sliding over the lining surface and its other end connected to a sensitive selsyn-instrument effecting in its turn control over the rate of the platform rotation in such a manner that in the case of deviation of the lining plane and turn of the over-hanging lever the speed of the sand-blast head circumferential movement is accordingly changed.

This provides for automation of the process of control over the apparatus, for example, automatic maintenance of a constant level of the lining surface at any time with respect to the shaping support.

And, finally, in accordance with the invention, the carriage has a collapsable knife secured in the zone of the sand-blast head and extandable radially into an operating position to cut off in a plane a part of the lining during the platform rotation.

This allows to mechanize preparation of planning the upper layer of the ladle lining to be covered with one or two rows of refractory bricks, and improves the quality of the lining-brick joint, and planning it provides the plane with a certain profile.

The following detailed description of an exemplary embodiment of the present invention is given with reference to the accompanying drawings, in which:

FIG. 1 is a schematic illustration clarifying the inventive method of lining ladles and shows the forces acting on the lining layer being filled;

FIG. 2 shows an apparatus for lining ladles, according to the invention, being a general view at the beginning of the operating position;

FIG. 3 shows a cross-section of the rod with the race of the apparatus as shown in FIG. 2;

FIG. 4 shows a view of the sand-blast head with a shield, shaping support and sensor of the control of the level of the lining variable plane with respect to the shaping support in the apparatus as shown in FIG. 2;

FIG. 5 shows a cross-section taken along line V—V in FIG. 4; and

FIG. 6 shows a band shaping support, according to the invention, in the apparatus as shown in FIG. 2.

In order to obtain a high-quality working layer of the lining owing to increased density of the latter, it is suggested to tramp the lining by applying simultaneously at least two active forces, of which one is an impact force Q (FIG. 1) developed by the sand-blast head and applied from above perpendicularly to the layer being filled along the lining wall of a ladle 1, and the other is a force P applied in the direction normal to the wall of the ladle 1 and developed by a special shaping support in the zone of action of the impact force Q.

These forces tramp the refractory mass in a space confined by the wall of the ladle 1 and the special shaping support, as it will be clarified below.

An object that is to be lined, in this particular case the steel-teeming ladle 1 (FIG. 2), is mounted on support beams 2 of a pit 3 for servicing ladles. Laid on the base walls of the pit 3 is a rail 4 over which roller carriages 5 of a gantry 6 move.

The gantry 6 is essentially an assembled metallic structure consisting of separate metallic elements. All the metallic elements of the gantry 6 are welded from plate steel material, and the gantry 6 proper serves as a basis on which all the units of the apparatus are mounted.

Mounted on the upper platform of the gantry 6 is a drive 7 of a mechanism for vertical displacement of a rod 8. The rod 8 is essentially a hollow welded metallic structure of a rectangular cross-section, and it has reinforcing ribs and toothed racks 9 disposed on its opposite edges along the whole length of the rod 8 for displacement and engagement with gears 10 of the drive 7 of the mechanism for vertical displacement of the rod 8.

Fastened to the angle of the rod 8 (FIG. 3) along the whole length of displacement of the rod 8 are prismatic guides 11 that hold the rod and all the mechanisms disposed thereon in the vertical position by means of guiding rollers 12 oriented along the diagonals of the rod 8 cross-section and secured in a race 13 mounted on the upper platform of the gantry 6. Provided on the hollow rod 8 is a vertical box 14 ensuring supply of refractory mass from a batching feeder 15 (FIG. 2), disposed on the upper platform, to a belt conveyor 16 arranged under the rod 8 on a turnable platform 17.

The batching feeder 15 is designed to continuously feed a predetermined amount of refractory mass from a bin 18 into the hollow rod 8.

Arranged above the batching feeder 15 is a displaceable electromagnet 19 designed to remove ferromagnetic metalic objects from the moving flow of the refractory mass.

Provided on the lower portion of the rod 8 is a support 20 (FIG. 2) bearing a drive 21 of a mechanism 22 rotating the turnable platform 17, this mechanism operating on the principle of internal gear engagement.

The hollow rod 8 terminates in a support plate 23 having a circular collector 24 fastened thereto and used for supplying electric energy to the drives of the mechanisms disposed on the turnable platform 17, and thrust balancing rollers 25 resting loads during rotation of the turnable platform 17.

The turnable platform 17 is provided with guiding rails (not shown in FIG. 2) disposed in the lower portion thereof, over which rails a carriage 26 mounting at least one sand-blast head 27, the belt conveyor 16 and a shaping support 28 are moved by a mechanism 29 for diametrical movement of the carrige 26.

By its design the sand-blast head 27 is analogous to a conventional sand-blast head, and differs from the latter only by disposition of the port for charging refractory mass on the head housing and the way in which the sand-blast head is fastened to the frame of the carriage 26, which is necessitates by the fact that the sand-blast head 27 is to be disposed as close to the ladle 1 wall as possible.

The sand-blast head 27 is rotated by an electric motor 30 connected to the sand-blast head 27 via an intermediate shaft 31.

The belt conveyor 16 mounted on the carriage 26 of the turnable platform 22 is disposed at the point of outlet of the rod 8 and ensures constant receipt of refractory mass from the rod 8 during rotation of the turnable platform 22 and its supply into the sand-blast head 27.

Provided on the frame of the carriage 26 under the sand-blast head 27 is a flow of refractory mass from that head 27. A sheet 32 (FIG. 4) of a certain length is shaped along the circumferential line of the lining being filled, and can be disposed relative to the ladle 1 wall in order to obtain a lining layer of a minimal thickness.

Mounted under the guiding sheet 32 is the snapping support 28 intended for obtaining the necessary space between the ladle 1 wall and the snapping support 28 to be filled with the refractory mass thrown out by the sand-blast head 27, and serving as a local gauge moving together with the sand-blast head 27.

Depending on the type and properties of the refractory mass used the shaping support 28 can be of any embodiment.

For example, the shaping support can be made as rotating rollers 33, 34 (FIG. 6) oriented by their axes parallel to the generating line of the surface of the ladle 1 and, the lining being filled embraced by a flexible band 35 in such a manner that it can move freely over the rollers 33, 34 when the shaping support 28 rolls over the lining being filled. The shaping support 28 is connected to the carriage 26 of the turnable platform 17 by means of a joint 36 whose operating axis is normal to the support surface of the flexible hand 35 of the shaping support 28 whose shape is identical to the circumferential line of the completed lining.

This design of the shaping support 28 allows the flexible band 35 of the shaping support 28 to roll over the working layer of the lining without damaging the latter, whereas the joint connection of the shaping support 28 with the carrige 26 makes it possible for the shaping support 28 to self-adjust during the movement of the turnable platform 17 by the helical line.

In the case of a fine refractory mass of a sufficient moulding softness, use is made of a shaping support 37 (FIGS. 4, 5) made from a rigid wear-resistant metallic shield shaped along the circumferential line of the lining being filled. The base of the shaping support 37 (FIG. 5) is secured to the carriage 26 by means of special bolts 38 which allow to orient it in any required position with respect to the surface of the lining being filled.

When the lining is being filled the operator is to maintain a constant distance between the sand-blast head 27 and the variable surface 8 of the lining being filled over its entire perimeter. In doing this he gets help from the sensor of the level of the instantaneous surface of lining, mounted on the carriage 26 (FIGS. 4, 5) and made as an overhanging lever 39 made turnable in the diametrical plane of the platform 22, and having a contact shoe 40 attached to its free end and sliding over the surface S of the linging at any time, and its other end connected through a toothed engagement **41, 42** (FIG. 7) with a sensitive instrument **43** (FIG. 5) which, in its turn, effects control over the speed of movement of the turnable platform **2**.

the contact shoe **40** of the sensor of the level of the instantaneous surface of the lining is extended forward with respect to the shaping support with the sand-blast head **27** in order to take into account the time lag of actuation of the drive of the mechanism for rotation of the turnable platform **22**.

Provided from the rear side of the sheet **32** in the zone of the sand-blast head **27** is a collapsible gliding knife **44** (FIGS. **4, 5**) designed to cut off the upper portion of the lining to make it fit one or two rows of refractory bricks. The cutting is effected during the reverse rotation of the turnable platform **22**. The blade of the knife **44** is of a tooth-like shape, which makes it possible to obtain a rough surface after the upper layer is cut off, which attributes to an improved fitting of the brick row and the filled lining. The collapsable gliding knife **44** is brought from its operating radial position into the non-operating one with the aid of a joint **45** specially provided for the purpose.

The apparatus operates as follows, the ladle **1** is placed onto the support beams **2** of the service pit **3**, and is centered thereon in such a way that the axis of the ladle **1** coincides with the axis of the rail **4**. By means of the driven roller carriages **5** mounted on the gantry **6** the apparatus moves onto the ladle **1** and stops thereon in such a manner that the vertical axis of the rod **8** coincides with the vertical axis of the ladle **1**. With the drive **7** switched on, the rod **8** and the support plate **23** of the turnable platform **17** move down towards the bottom of the ladle **1** and the shaping support **28** (in which case the terminal switched operates at the lowermost position not shown in FIG. **2**.

During the lowering of the rod **8** there is set up the necessary space or gap between the protective lining of the ladle **1** and the shaping support **28**, which is attained as a result of the diametrical movement of the carriage **26** with the sand-blast head **27** mounted thereon by means of the mechanism **29** for diametrical movement of the carriage **26**.

When the test rotation of the turnable platform **17** in the ladle **1** is terminated, the drive **21** of the mechanism **22** of rotation of the turnable platform **22** is switched on to provide the optimum mode of operation, and so are the mechanisms for supplying the refractory mass.

Then, the batching feeder **15** is switched on to feed refractory mass from the bin **18** (the bin **18** is loaded with refractory mass beforehand) into the vertical box **14** of the rod **8**. In the course of its movement through the batching feeder **15** the refractory mass is cleaned of ferromagnetic materials with the aid of the electromagnet **19**.

Through the vertical box **14** the refractory mass gets onto the belt conveyor **16** which delivers it into the sand-blast head **27**. The operating member, i.e. the rotor (not shown) of the sand-blast head **27** is rotated by the electric motor **30** through the intermediate shaft **31**. The sand-blast head **27** disposed on the carriage **26** of the turnable platform **17**, together with the shaping support **28**, feeds the refractory mass into the space between the wall of the ladle **1** and the shaping support **28** until the height of the lining equals that of the shaping support **28**. Hereafter the drive **7** is switched on, and the rod **8** is imparted upward movement through the gears **10** and the racks **9**. Concurrently, the drive **29** with the diametrical movement of the carriage **26** with the sand-blast head **27** and the shaping support **28** is switched on, and the ladle **1** is started being lined along the helical line, with the radius of the lining increasing as the rod **8** moves higher.

On getting into the sand-blast head **27** (FIG. **1**) the refractory mass is started being tramped in the space confined by the ladle **1** wall and the shaping support **28** mounted under the sand-blast head **27** by two active forces of which one is the impact force Q developed by the sand-blast head **27** and applied perpendicularly to the upper surface of the lining being filled, and the other force is designed P, developed by the shaping support **28** and applied in the direction normal to that of the impact force Q in the zone of the lining being filled. The distance between the sand-blast head **27** and the prevailing surface of lining remains optimally constant, and is determined by the dimensions of the sheet **32**.

In order to maintain constant the distance between the sandblast head **27** and the variable surface of lining, which may vary for reasons that do not depend on one another (non-uniform supply of the mass, inaccurate centering of the apparatus with respect to the ladle), the contact shoe **30** (FIGS. **4, 5**) fastened to the overhanging lever **39** moves over the surface of the lining being filled and, in the case of deviations in the level of the surface S of the lining being filled with respect to the shaping support **28**, starts vibrating, thereby bringing into rotation the sensitive instrument **43** through the toothed sector **42** and the gear wheel **41** mounted on the shaft of the instrument **43**. In the case of downward deviation of the feeler with the lever **39** from the nominal value, the shaft of the instrument **43** will rotate in one direction, and in the case of upward deviation, in the other.

By electrical signals received due to oscillations of the contact show-feeler **40**, the instrument **43** either increases or decreases the circumferential speed of movement of the sand-blast head **27**, as a result of which the variable surface S (FIG. **1**) of the lining being filled is levelled up with respect to the shaping support **28**. As the amount of the refractory mass thrown by the sand-blast head **27** onto the surface S of the lining per time unit is always constant, it is possible by changing the speed of circumferential movement of the sand-blast head **27** to vary the amount of the mass thrown onto the (variable) surface S of the lining by levelling up and maintaining constant the level of the surface of the lining layer being filled with respect to the shaping support **28**.

In the course of lining of a ladle there is obtained a uniform density of tramping of the refractory mass over the entire height of the ladle owing to the fact that the refractory mass is tramped by the sand-blast head **27** in such a way that the distance between the sand-blast head **27** and the surface S of the lining (FIG. **1**) remains constant, and the mass is additionally tramped by the shaping support **28** whose force is applied from the side of the lining operating layer.

The density of lining after the tramping process varies within narrow limits, and constitutes **95** to **97** units as measured by the Foundry Hardness Meter.

In the course of their use the linings of ladles wear out non-uniformly over the height of the ladle, and, therefore, it is expedient to make its thickness different along the height of the ladle, i.e. to make it thicker in the spot of more intensive wear-out of the lining and thinner in the spots of less intensive wear out.

For this purpose the apparatus for lining ladles is provided with the carriage **26** having the mechanism **29** for diametrical movement, mounted on the turnable platform **17**.

The mechanism **29** allows for a fast change in the radius of circumferential movement of the sand-blast head **27** with the shaping support **28** relative to the vertical axis of the rod **8** and, thus, to obtain the required profile of the lining being filled.

With the lining process over, the mechanisms for supplying the refractory mass and the sand-blast head **27** are switched off, the gliding knife **44** is brought by means of the joint **45** from its non-operating position into the radial operating poition, and, by rotating the turnable platform **17** in the direction opposite to the operating one and simultaneously lowering the rod **8**, the upper layer of the lining is cut off (planed) until the surface is leveled up over the entire perimeter of the ladle to make it possible to place one on two rows of refractory bricks. Thereupon the movement of the turnable platform **17** is discontinued, the rod **8** is raised in its extreme upper position, the terminal switch (not shown in the drawings) starts operating, and the apparatus for lining ladles moves off the service pit, to be prepared for lining another ladle.

Control over the actuating mechanisms of the apparatus is effected by means of universal switches, knob stations and control knobs disposed on two control panels (not shown) of which one is the main and the other is auxiliary.

The electric control circuit provides for possibility of controlling the apparatus both in adjusting and automatic modes of operation.

In the case of the adjusting mode of operation all the actuating mechanisms are switched on autonomously in order to check their operability and to adjust the apparatus for filling a lining of a required profile in a ladle of a certain type and size.

In the automatic mode of operation the apparatus is controlled from a central control board (not shown).

The automatic mode of operation provides for switching on of necessary interlocks (the driven roller carriages **5** of the gantry **6** are switched off).

The sand-blast head **27**, the belt conveyer **16** and the batching feeder **15** are switched on in a required sequence automatically, wherein in case one of the mechanisms is not switched on the other mechanisms connected with it by the technological sequence are automatically interlocked from being switched on.

The electric control system provides for an emergency switch off of the actuating mechanisms of the apparatus.

The electric control circuit of the actuating mechanisms provides for their operation within a wide range in accordance with the required technical characteristics of the apparatus, from which some data can be cited as an example.

The output of the sand-blast head in the case of untramped mass is 40 m^3/hr. The refractory mass jet is thrown out of the sand-blast head at a rate of 60 m/sec. The power of the electric motor of the drive of the operating member of the sand-blast head is 100 Kwt. The (controllable) speed of the vertical displacement of the rod is 0.1 to 0.4 m/min, with the rod pitch being **4100** mm. The (controllable) rotation rate of the turnable platform is 2 to 7.5 rpm. The speed of the gantry movement is 10 m/min. The time required for lining a 160 *t* ladle is 1 hour 30 min. The minimum thickness of the lining working layer is 160 mm, the maximum thickness of the layer being 260 mm. Use is made of a refractory mass having a humidity of 6 to 9% based on natural refractory sand.

In order to obtain a high-quality working layer of a ladle wall lining, it is necessary to observe the following technological requirements set forth with respect to both the refractory mass used and the modes of the apparatus operation.

The refractory mass should be fine and uniform, have a humidity of 7 to 9% and be based on natural refractory sand with a clay content of around 12%.

The refractory mass should be uniformly delivered from the bin in an amount providing for sufficient loading of the sand-blast head, operating at a rate of 40 m^3/hr.

The rotation drive of the turnable platform **22** should ensure a stable speed of the circumferential movement of the turnable platform within its range, both under load and without it.

The lifting drive of the rod **8** should ensure uniform lift of the rod both under load and without it.

What we claim is:

1. A method for high-density lining inner spaces, confined by the inner surface of a ladle and by a backing shaping element therein, with a refractory mass along the inner circumferential perimeter of the ladle wall and along the entire height thereof, comprising the steps of:
   - feeding the mass at a speed of 60 m/sec. into spaces confined between the inner surface of the ladle and the backing shaping element therein along a helical trajectory;
   - applying the fed-in mass to the inner surface with at least one blasting means in close proximity to the inner ladle perimeter, with a force applied perpendicularly to the upper surface of the lining layer as the lining is being applied;
   - positioning the backing shaping element initially at a distance equal to the initial thickness of the lining in the bottom of the ladle;
   - imparting to the blasting means a continuous circular movement along the inner perimeter and parallel thereto;
   - positioning the backing shaping element behind the blasting means and free of physical contact with the inner ladle perimeter to ensure a predetermined narrow gap being filled with the mass to deliver the refractory mass along the ladle wall being lined into said space between the ladle wall and the shaping element;
   - additionally imparting to the blasting means continuous vertical movement along the entire height of the ladle as the lining is completing the perimeter; the backing shaping element also being moved upward continuously, in addition to and simultaneously with its continuous circular movement along the inner ladle perimeter;
   - maintaining the distance between the blasting means and the upper surface of the lining constant during the vertical movement to create identical conditions for the passage of the refractory mass applied to the blasting means;
   - maintaining the lining layer at a minimum thickness in accordance with the narrow gap;
   - simultaneously and continuously moving the blasting means radially with respect to the surfaces being lined, together with the backing shaping element, thereby obtaining a continuous and successive fill-

ing of the lining with the minimum thickness along a helical trajectory over the entire height of the ladle; and,

reducing the scattering of the mass by the blasting means during said feeding and said applying steps.

2. The method as defined in claim 1, further comprising the steps of: subjecting the refractory mass, during said feeding step, to the simultaneous action of at least two forces, of which one is an impact force developed by the at least one blasting means, applied along the inner ladle surfaces that are being lined and parallel thereto, from above, perpendicularly to the lining layer, while the other force is applied in a direction normal to the inner surfaces being lined, in the zone to which the lining is fed.

3. The method as defined in claim 1, further comprising the step of: compressing the refractory mass that is being applied with the at least one blasting means, by the application of the impact force developed by the blasting means.

4. The method as defined in claim 1, wherein the distance between the blasting means and the upper surface of the lining is maintained constant by sensing deviations in the level of the upper surface of the lining as the fed-in mass is applied.

5. The method as defined in claim 1, including the steps of:

directing the refractory mass transversely and normally towards the inner circumferential perimeter of the ladle wall solely with the shaping element, and

directing the refractory mass in a direction parallel to the inner circumferential wall solely with the blasting means.

6. The method as defined in claim 5, including the step of:

directing the refractory material towards said inner circumferential perimeter with the blasting means and the shaping element being free of contact with the ladle wall.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,094,938

DATED : June 13, 1978

INVENTOR(S) : Serafim Vasilievich Kolpakov et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 14, "sand-blast, head," should be "sand-blast head,"

Col. 1, line 22, "U.S." should be "is"

Col. 1, line 40, "limits, a deviation" should be "limits, as a deviation"

Col. 1, line 51, "snaping" should be "shaping"

Col. 2, line 28, "are accomplished: that, in" should be "are accomplished in that,"

Col. 2, line 31, "as fed" should be "is fed"

Col. 2, line 42, "the helical" should be "a helical"

Col. 2, line 44, "the lining" should be "the lining,"

Col. 2, line 51, "into fragments" should be "into fragments,"

Col. 3, line 4, "movement of at least one sand-blast head" should be "movement of the head"

Col. 5, line 32, "rod 8" should be "rod 8,"

Col. 5, line 35, "angle" should be "angles"

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PATENT NO. : 4,094,938

DATED : June 13, 1978

INVENTOR(S) : Serafim Vasilievich Kolpakov et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 6, line 6, "necessitates" should be "necessitated"

Col. 6, line 19, "head 27." should be "head."

Col. 6, line 23, "snapping" should be "shaping"

Col. 6, line 25, "snapping" should be "shaping"

Col. 6, line 35, "land," should be "1, and"

Col. 6, line 68, "linging" should be "lining"

Col. 7, line 5, "the contact" should be "The contact"

Col. 7, line 20, "collapsable" should be "collapsible"

Col. 7, line 35, "switched" should be "switch"

Col. 7, line 35, "position not" should be "position, not"

Col. 7, line 36, "Fig. 2." should be "Fig. 2)."

Col. 7, line 45, "of rotation of the turnable platform 22" should be deleted

Col. 7, line 68, "with the diametrical movement of the carriage

Col. 8, line 1, 26" should be deleted

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,094,938

DATED : June 13, 1978

INVENTOR(S) : Serafim Vasilievich Kolpakov et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 8, line 13, "force is designed P," should be "force is designated,"

Col. 8, line 20, "sandblast" should be "sand-blast"

Col. 8, line 47, "(variable)" should be "variable"

Col. 9, line 14, "poition" should be "position"

Col. 9, line 19, "one on two" should be "one or two"

Col. 9, line 64, "m/min," should be "m/min.,"

Signed and Sealed this

Fourth* Day of *September 1979

[SEAL]

Attest:

LUTRELLE F. PARKER

Attesting Officer *Acting Commissioner of Patents and Trademarks*